National Aeronautics and Space Administration
Jet Propulsion Laboratory
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TPF Terrestrial Planet Finder

The Lighter Side of TPF – evaluation the scientific gain from different architectures

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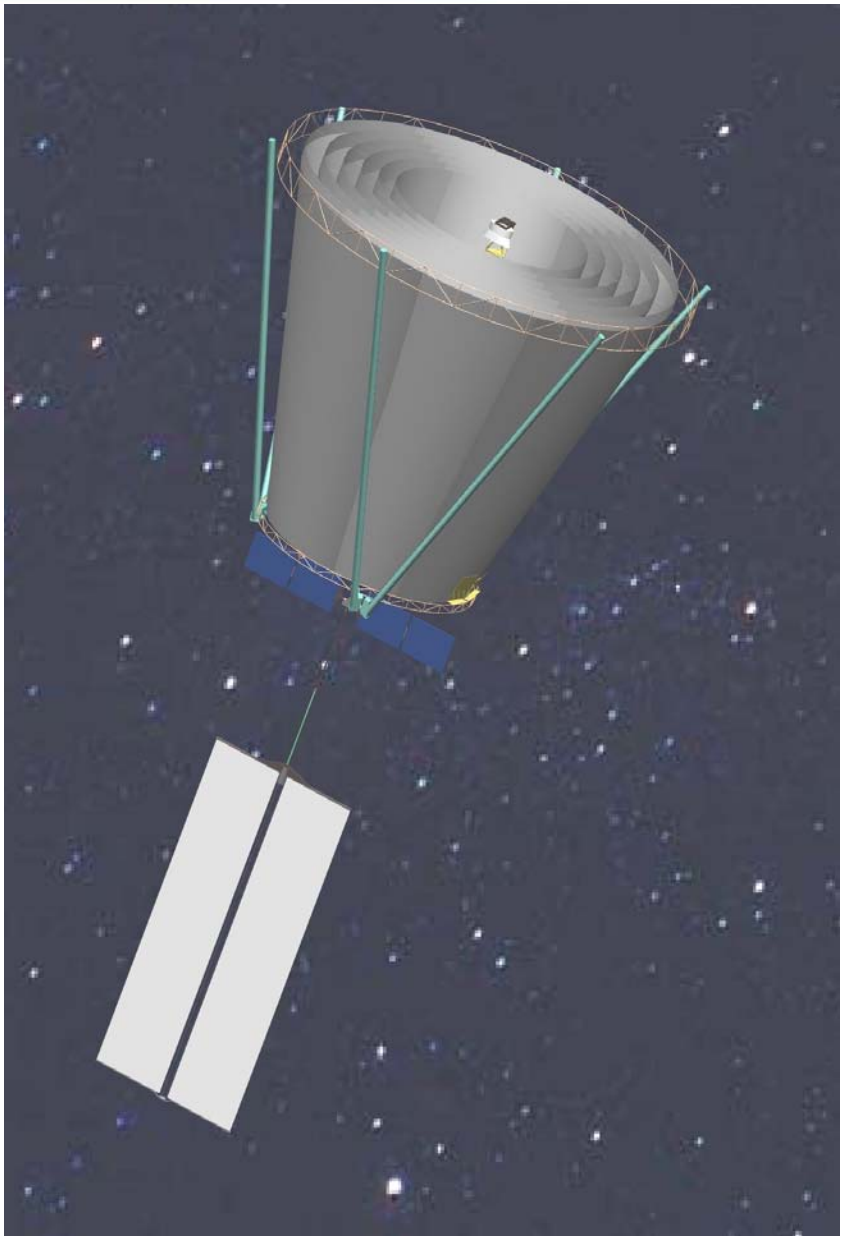
Exoplanet Science and Technology Fair

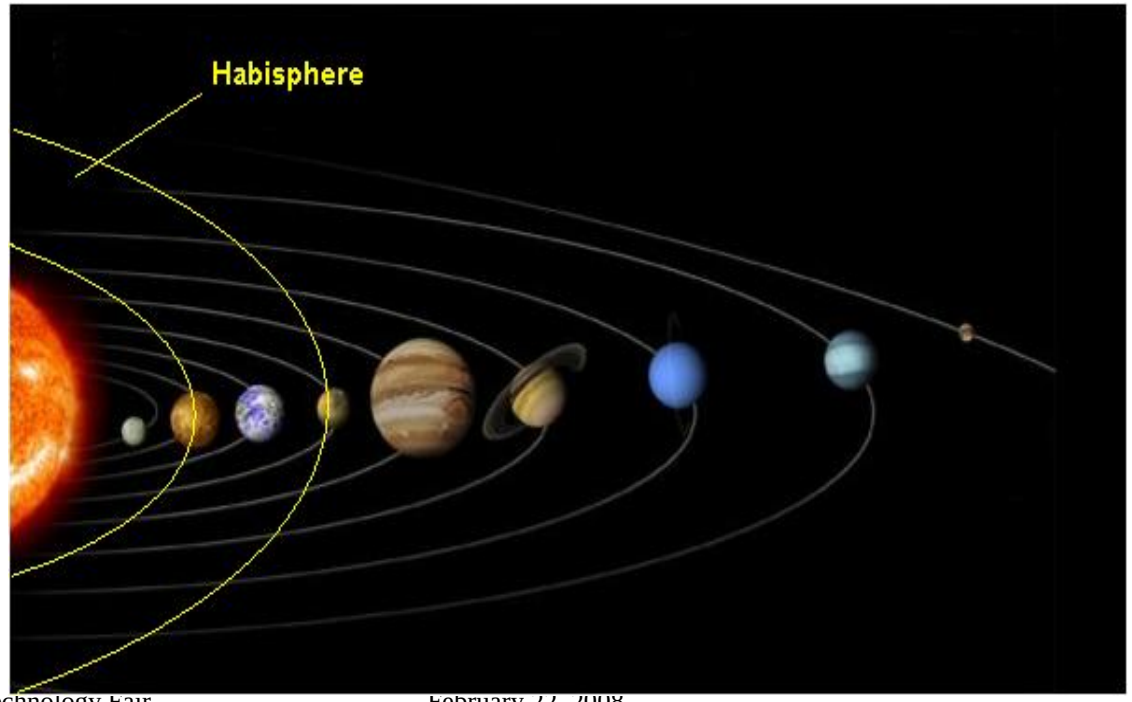


Overview

- Brief overview of completeness
- Overview of program completeness
- Parameters and assumptions
  - Planet parameters
  - Telescope parameters
- Definition of terms
- Results
- Conclusions

Completeness

- Each star has a habitable zone which is determined by the stellar luminosity and mass
- In order to define this habisphere we populate the habitable zone of the given star with 10,000 planets in random orbits with eccentricities from 0 to 0.1
- Completeness is the fraction of planets that we are able to observe in a single stellar visit.
- Total accumulated completeness is the sum of all the completeness values for all the stars over the mission duration.
- For η_{earth}=1, the total accumulated completeness is equal to the expected number of detections.



Terminology

	Type	IWA (l/Dmax)	Min. Revisit Time	Overhead	Primary Mirror
Large-class Mission (> $2B)					
TPF-I	Classic-X Array	2.5	2 wk	70% eff	4 @ 4 m plus beam combiner spacecraft
TPF-C	Flight Baseline - 1	4	3 wk	2 hrs	8 m x 3.5 m
TPF-C	Flight Baseline - 1 with Pupil Mapping (PIAA)	4	3 wk	2 hrs	8 m x 3.5 m
TPF-O	External Occulter (Dual)	~2.5	1 / 3 wk	6 / 20 days	4m telescope + 25m and 50m occulter
Mid-class Mission (< $2B)					
TPF-I	Emma-X Array	2.5	2 wk	70 % eff	4 @ 2 m plus beam combiner spacecraft
TPF-C	Shaped Pupil. BL Mask or Visible Nuller	3.5	3 wk	2 hrs	4 m
TPF-C	Pupil Mapping (PIAA)	3.5	3 wk	2 hrs	4 m
TPF-C	Pupil Mapping (PIAA)	2.5	3 wk	2 hrs	4 m, aggressive IWA
TFF-O	External Occulter (Large)	~2.5	3 wk	20 days	4 m telescope + 50 m occulter @ 72000 km
TFF-O	External Occulter (Small)	~2.5	1 wk	6 days	4 m telescope + 25 m occulter @ 30000 km
Small-class Mission (< $1B)					
TPF-C	Shaped Pupil, BL Mask or Visible Nuller	3.5	3 wk	2 hrs	2.5 m
TPF-C	Pupil Mapping (PIAA)	3.5	3 wk	2 hrs	2.5 m
TPF-C	Pupil Mapping (PIAA)	2.5	3 wk	2 hrs	2.5 m, aggressive IWA
Aggressively small-class Mission (~ $600M)					
TPF-C	Pupil Mapping (PIAA)	2.5	3 wk	2 hrs	1.5 m, aggressive IWA

TPF Terrestrial Planet Finder

Planet Search Parameters

Earth-twin
- $R_p = 1$
- HZ = 1 AU or 1.5 AU
- Albedo = 0.2

Super-Earth
- $R_p = 2$
- HZ = 1 AU or 1.5 AU
- Albedo = 0.2

Super-Earth with gas envelope
- $R_p = 4.2$
- HZ = 1 AU
- Albedo = 0.4

Jupiter-twin
- $R_p = 11$
- HZ = 5 AU
- Albedo = 0.44

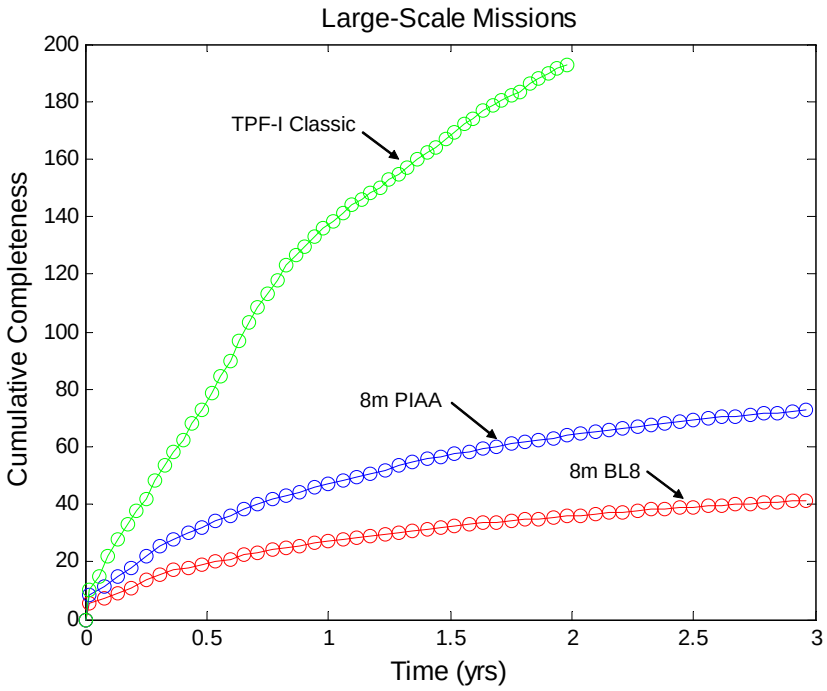
Saturn-twin
- $R_p = 9.1$
- HZ = 9 AU
- Albedo = 0.47

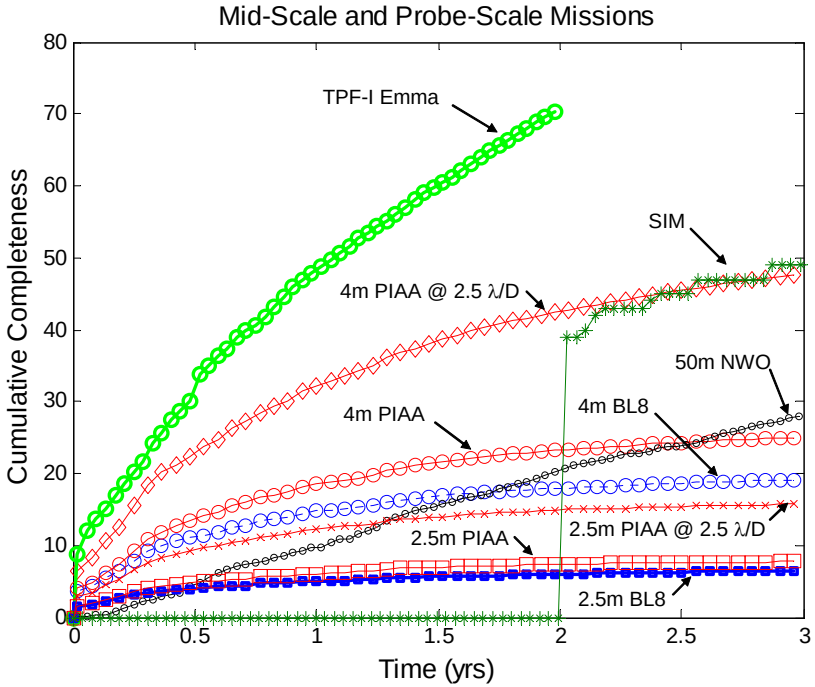
- All planets were uniformly distributed in semi-major axis.

Smaller-Scale Missions

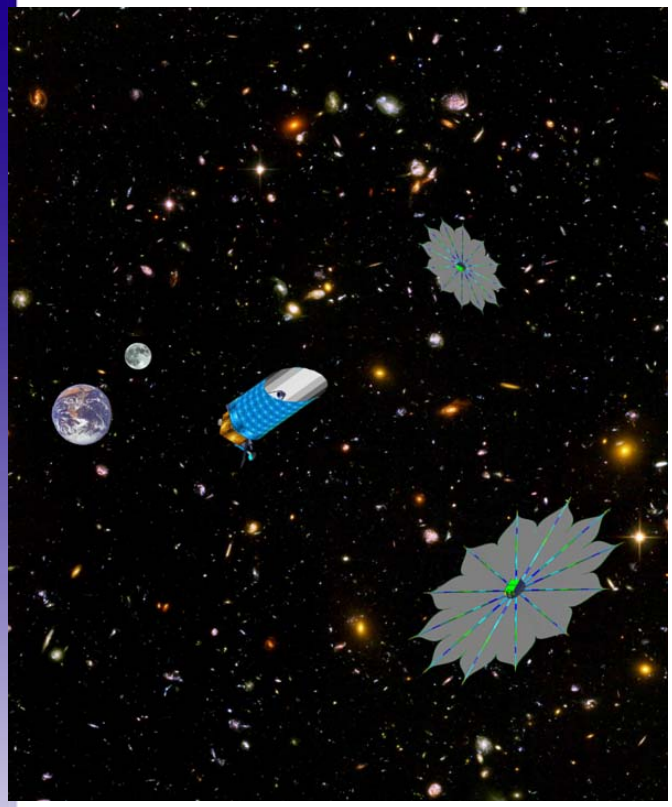
- With circular mirrors, the telescope rolls can be eliminated (but not the dither). This reduces integration time by a factor of 3.
- This in turn helps performance at smaller IWA (i.e. $4\lambda/D \rightarrow 2.5\lambda/D$).
- Lower completeness with smaller mirror is partially offset by a more aggressive IWA.
- Significant numbers of Jupiter size planets can be observed and characterized with the smallest missions.

Results – Large and Mid-Scale





Results - Occulter



Occulter Scenario	$\eta_{Jupiter}$	Targets	Completeness
Small	N/A	60	23.46
Large	N/A	63	28.39
Dual	0.1	2	1.25
Dual	0.3	17	6.30
Dual	0.5	28	10.73
Dual	0.7	39	14.46
Dual	1.0	50	17.38

Luminosity and Completeness for Selected Cases

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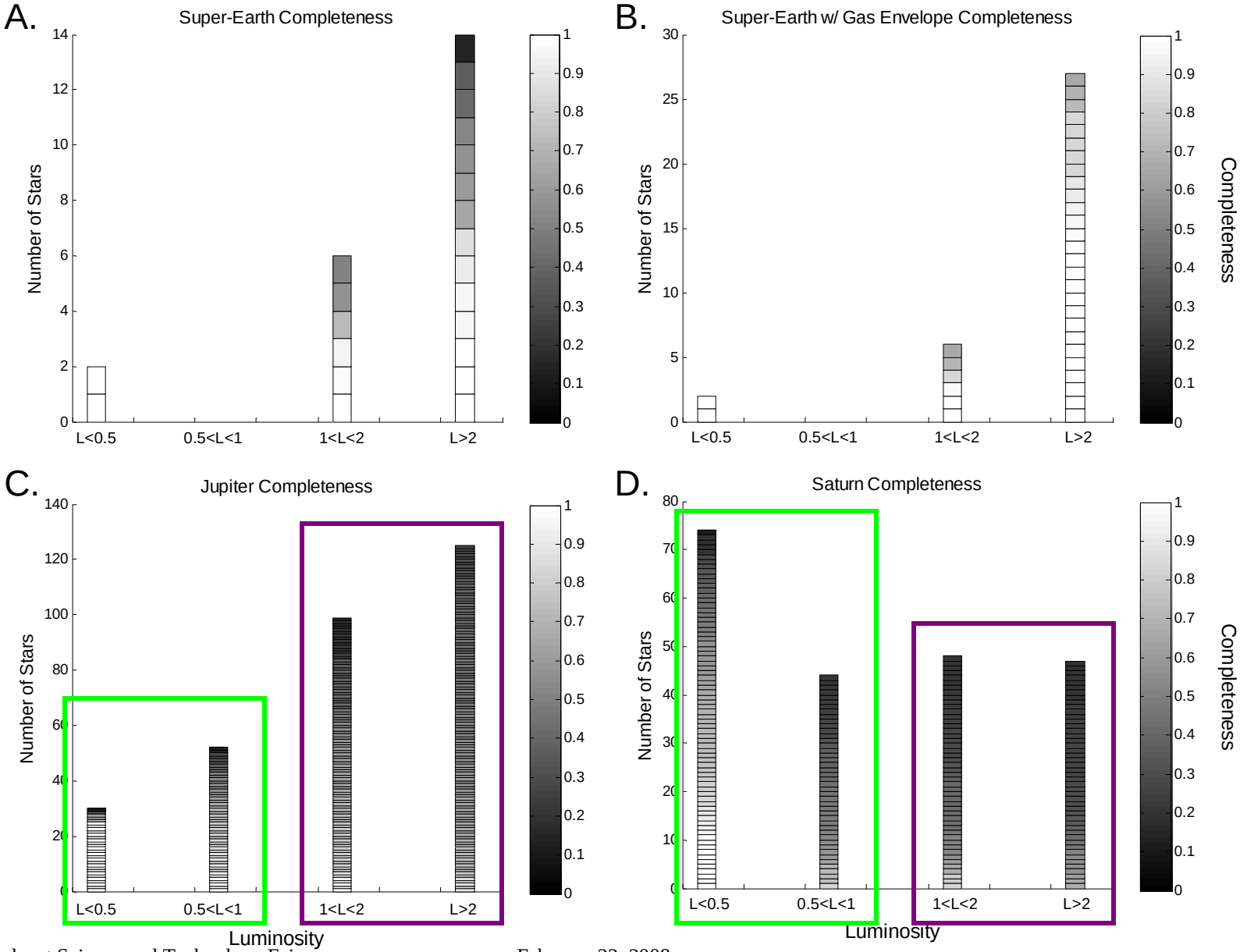

Conclusions

- Large and Medium class missions provide the best potential for finding Earth like planets
- While there are few Earth-twin planets that are visible with a smaller mission, there are many detectable Solar-System analog planets.
- The current dual-occulter scenario does not perform better than a single small or large single occulter.
- New technology (aggressive IWA PIAA coronagraph) doubles the number of planets detected.
  - Studying ability to meet stability requirements.
- The type of stars visited changes drastically for different planet observing programs.
- ½ of mission time is available for characterization and other science.
  - Revisiting for characterization is possible in 6 month windows.
- We continue to perform analyses in terms of orbit determination and characterization.

Questions?